DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOP
U.S. BUREAU OF L

INTRODUCTION

Previous water-level maps of shallow aquifers in the Powder River structural basin in Wyoming were based on water levels from wells completed in different stratigraphic intervals within thick sequences of sedimentary rocks. A potentiometric surface using water levels from a single aquifer had never been mapped throughout the basin. The sandstone aquifers in the Fort Union Formation of Paleocene age and the Wasatch Formation of Eocene age are discontinuous and lenticular, and do not extend even short distances. Coal aquifers are more continuous and the Wyodak-Anderson coal bed, in the Fort Union Formation, has been mapped in much of the Powder River structural basin in Wyoming. Water-level altitudes in the Wyodak-Anderson coal bed and other stratigraphically equivalent coal beds were mapped to determine if they represent a continuous potentiometric surface in the Powder River structural basin. The potentiometric surface, except in the vicinity of the Wyodak mine east of Gillette, represents a premining condition as it was based on water-level measurements made during 1973-84 that were not significantly affected by mining. The map was prepared in cooperation with the U.S. Bureau of Land Management.

The Wyodak-Anderson coal bed is extensively mined along the outcrop in eastern Campbell County. More coal is produced from the Wyodak-Anderson coal bed than from any other single coal bed in the Nation (Lowry, Wilson, and others, in press, p. 34). Presently (1984), all mining of the Wyodak-Anderson coal bed is by surface methods.

SITE-NUMBERING SYSTEM

Wells and springs in this report are numbered according to their location within the Federal system of land subdivision. The first number denotes the township north from the 40th Parallel Base Line, the second number denotes the range west from the Sixth Principal Meridian, the third number denotes the section, and the letters denote the location within the section. Subdivisions within a section are lettered A, B, C, and D in a counterclockwise direction beginning in the northeast quarter (A - NE1/4, B - NW1/4, C - SW1/4, D - SE1/4). The first letter denotes the quarter section (160 acres), the second letter the quarter-quarter section (40 acres), and the third letter the quarter-quarter-quarter section (10 acres). A number after the letters distinguishes that well from others assigned a sequential number in the same subdivision.

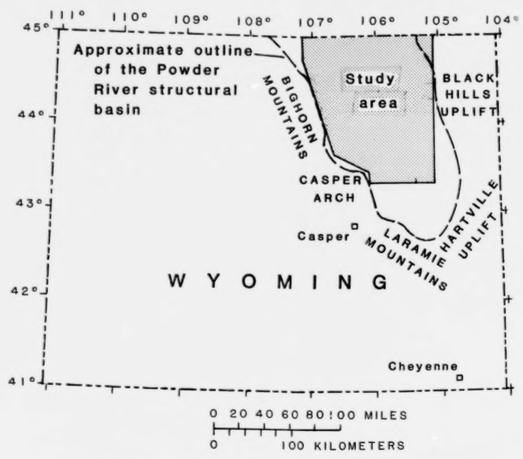
GEOLOGY

The Wyodak-Anderson coal bed occurs within the Powder River structural basin, which is bounded in Wyoming by the Black Hills uplift, the Hartville uplift, the Laramie Mountains, the Casper arch, and the Bighorn Mountains, and extends northward into Montana (see location map). The coal bed crops out in central Campbell County and dips westward to a depth of more than 2,000 feet in central Johnson County (N. M. Denson, U.S. Geological Survey, written commun., 1982). On the west side of the basin it crops out to the north but not to the south of Sheridan. Along the Wyoming-Montana State line the coal bed crops out in topographically low areas.

The Wyodak-Anderson coal bed is part of the Fort Union Formation and is in the Tongue River Member of the Fort Union where the Tongue River is mapped. The Fort Union Formation is overlain by the Wasatch Formation and underlain by the Lance Formation of Cretaceous age. The Wyodak-Anderson is assumed to be laterally continuous throughout the study area. The coal bed thickness ranges from about 3 to about 200 feet.

The following description of the Wyodak-Anderson coal bed is from Lowry, Wilson, and others (in press, p. 26):

> The subbituminous Wyodak coal bed is 25 to 175 feet thick, and probably averages 70 feet in thickness. The coal has variously been called the Wyodak-Anderson and the Anderson-Canyon coal bed. Because of correlation problems, the Wyodak coal bed was erroneously called the Roland-Smith coal bed in older reports. To the west of Gillette, the Wyodak coal bed separates into the Anderson and Canyon coal beds, with the 2 beds each 10 to 65 feet thick.
>
> North from Gillette, the Wyodak separates into an Upper Wyodak and Lower Wyodak. In places, the Upper Wyodak separates into the Smith, Swartz, and Anderson coal beds and the Lower Wyodak separates into the Canyon and Cook coals (Kent and others, 1980). When the Wyodak separates into 5 or more beds, the individual coal beds are 3 to 38 feet thick and separated by a few feet to 200 feet of claystone, shale, or sandstone. The Wyodak also separates into the Anderson coal (D bed) and the Canyon (E bed) southward from Gillette. Coals equivalent to the Wyodak also



Location of study area

EXPLANATION

CLINKER

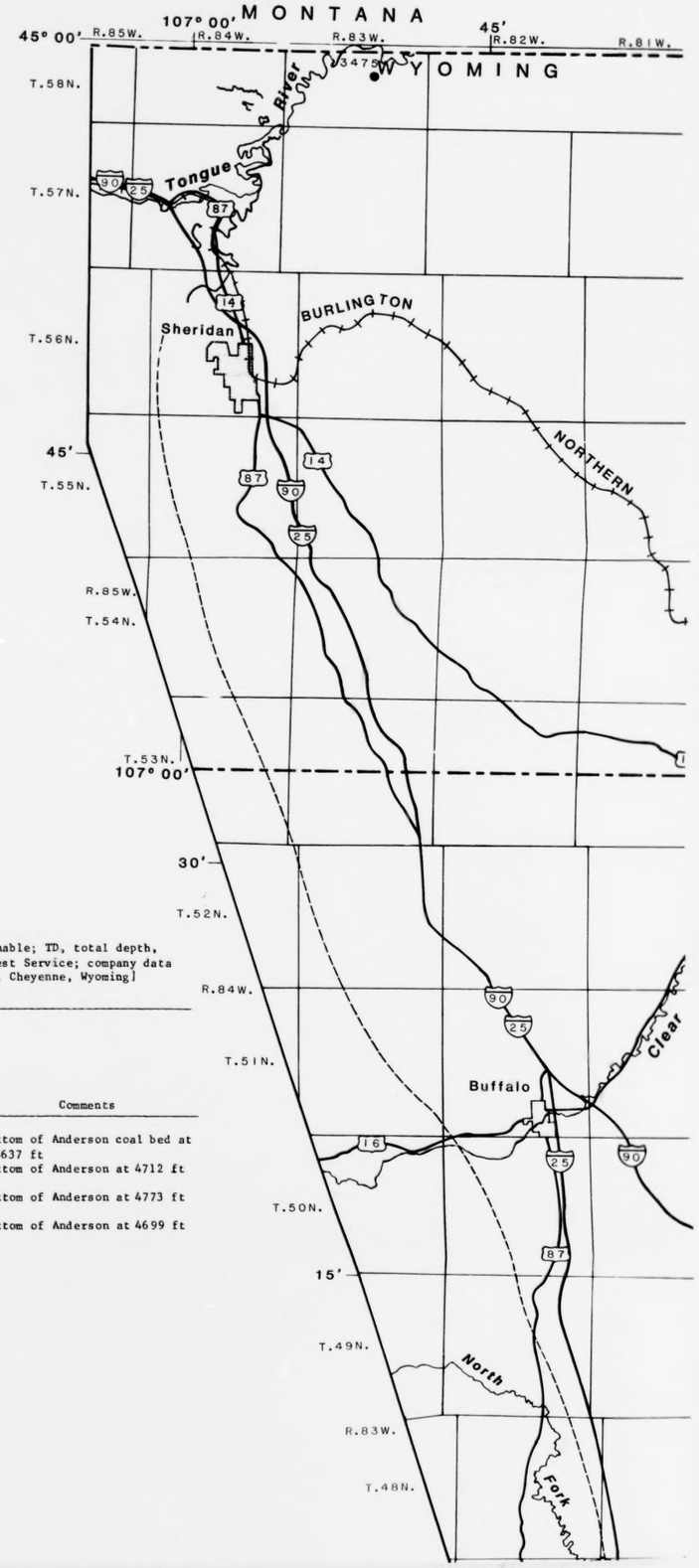
EXTENT OF WYODAK-ANDERSON COAL BED, STRATIGRAPHICALLY EQUIVALENT COAL BEDS, OR CLINKER--Dashed where approximately located, dotted where concealed

—3700— GENERALIZED POTENTIOMETRIC CONTOUR--Shows altitude at which water level would have stood in tightly cased wells completed in the Wyodak-Anderson coal bed. Dashed where approximately located. Contour interval 100 feet. Datum is sea level

DATA SITE AND NUMBER--Shows location of well or spring. Number is altitude of water level, in feet above sea level. "Q" is used where the water level is questionable, as explained in "Comments" on table

38920 Well

4020 Spring



WATER-LEVEL DATA, WYODAK-ANDERSON COAL BED

[Abbreviations: <, well is dry, the altitude given is bottom of the coal bed; Q, water level questionable; TD, total depth, perforated interval unknown; ft, feet. Source of data: USGS, U.S. Geological Survey; USFS, U.S. Forest Service; company data are from mine plans submitted by the named company to the Wyoming Department of Environmental Quality, Cheyenne, Wyoming]

Site number	Water-level altitude (feet above sea level)	Water level (feet below land surface)	Water-level date	Well altitude (feet above sea level)	Perforated interval (feet below land surface)	Wyodak-Anderson interval (feet below land surface)	Well name	Source of data	Comments
40N 071W 09ADC01	<4637	Dry	10/81	4840	168-210	178-203	BR-9	USGS	Bottom of Anderson coal bed at 4637 ft
40N 071W 15CBC01	<4712	Dry	10/81	4940	210-231	211-228	BR-10	USGS	Bottom of Anderson at 4712 ft
40N 071W 17AAD01	4695	125	10/81	4820	105-126	104-121	BR-11	USGS	
40N 071W 23BCB01	<4773	Dry	07/78	4818	85-105	29-45	Wyodak-1	USGS	Bottom of Anderson at 4773 ft
41N 069W 06CAA01	4778	187	12/80	4965	138-200	--	42R17	Shell	
41N 070W 02DCC01	<4699	Dry	12/80	4930	168-231	--	42R19	Shell	Bottom of Anderson at 4699 ft
41N 070W 10BBA01	4642	57	12/80	4699	30-90	--	NA51	Shell	
41N 072W 29BAC01	4658	212	11/82	4870	462-504	485-526	TCSE-1	USGS	
42N 069W 31BBC01	4744	195	12/80	4939	171-211	--	42R11P	Shell	
42N 070W 03CBC03	4653	163	--	4816	TD 260	--	BTR-20	Arco	
42N 070W 33ACD01	4595	176	08/78	4771	205-255	178-258	SEAM-18	USFS	
43N 070W 17BA 01	4608	71	--	4679	TD 196	--	BTR-1	Arco	
43N 070W 27AB 01	4621	60	10/73	4681	TD 118	--	BTR-154	Arco	
43N 071W 05DCC01	4616	229	08/78	4845	572-593	--	CDLTR-12	USGS	
43N 071W 21ADB01	4605	190	07/79	4795	--	--	--	USGS	
45N 070W 04BBB01	4600	87	--	4687	TD 113	--	CCR-3	Arco	
45N 070W 20BBA01	4639	231	05/79	4870	230-251	--	CDH-2	USGS	
45N 071W 05BAD01	4612	108	05/77	4720	290-311	308-	--	USGS	
45N 072W 36BCC02	4600	175	12/77	4775	673-693	--	HWY	USGS	
46N 070W 16CCC01	4628	44	--	4672	--	--	CCR-22	Arco	
46N 070W 18AAA01	4582	70	--	4652	TD 140	--	CCR-27	Arco	
46N 070W 27BDD01	4712	24	--	4736	TD 70	--	CCR-13	Arco	
46N 070W 29AAA01	4596	102	--	4698	TD 155	--	CCR-15	Arco	
46N 070W 33ACC01	4660	103	--	4763	--	--	CCR-6	Arco	
46N 070W 34CAA01	4704	38	--	4742	--	--	CCR-7A	Arco	
46N 071W 02DAC01	4486	54	--	4540	--	--	CORD-9	Sunoco	
48N 070W 18ADA02	4665	84	05/76	4749	--	--	CA-317	Carter	
48N 071W 11CCC05	4466	87	05/76	4553	110-170	102-173	CA-321	Carter	
48N 071W 12BAA01	4518	96	05/76	4614	--	78-121	CA-319	Carter	
48N 071W 31CA 01	4457	43	11/79	4500	200-268	--	WRRI-10A	Amax	

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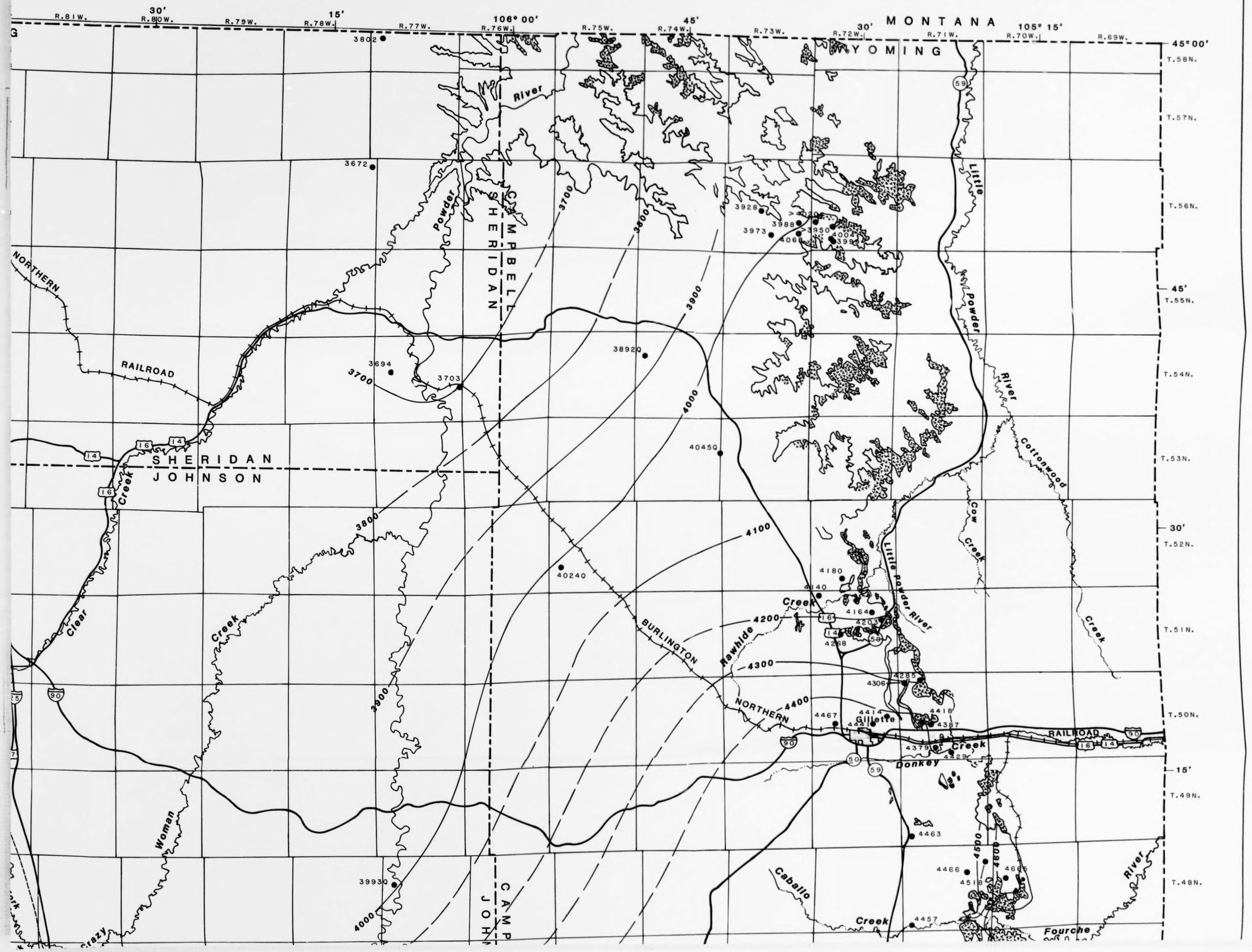
WATER-RESOURCES INVESTIGATIONS REPORT 85-4305



been called the Wyodak-Anderson and the Anderson-Canyon coal bed. Because of correlation problems, the Wyodak coal bed was erroneously called the Roland-Smith coal bed in older reports. To the west of Gillette, the Wyodak coal bed separates into the Anderson and Canyon coal beds, with the 2 beds each 10 to 65 feet thick.

North from Gillette, the Wyodak separates into an Upper Wyodak and Lower Wyodak. In places, the Upper Wyodak separates into the Smith, Swartz, and Anderson coal beds and the Lower Wyodak separates into the Canyon and Cook coals (Kent and others, 1980). When the Wyodak separates into 5 or more beds, the individual coal beds are 3 to 38 feet thick and separated by a few feet to 200 feet of claystone, shale, or sandstone. The Wyodak also separates into the Anderson coal (D bed) and the Canyon (E bed) southward from Gillette. Coals equivalent to the Wyodak also are tentatively correlated into the Sheridan area, Wyoming, 80 miles west of Gillette.

In eastern Johnson County the upper part of the Anderson combines with overlying coal beds to form a 201-foot-thick coal bed (Pierce and others, 1982, p. 262).

WATER-LEVEL DATA

Water-level data representing premining conditions were collected during 1973-84 from observation wells at coal mines along the eastern outcrop of the Wyodak-Anderson coal bed and from coal-test holes outside the mine areas. East of Gillette, mining began in the 1920's, and premining water-level data are not available. Water-level data outside the mine areas were from wells completed from coal-test holes by the U.S. Geological Survey and the U.S. Bureau of Land Management. No water-level data were available in the western part of the basin where the coal is more than 2,000 feet deep in central Johnson County. Site numbers, water-level measurements and dates, construction data, and well names are listed in the table

Because the extension of the potentiometric surface to the center of the map is based on one data point with a questionable water level, that water-level data is explained here. Well 48N 077W 07DDD01 was 1,255 feet deep and was perforated through 184 feet of the Big George coal bed, correlated with the upper part of the Anderson. The water level in the casing and annular space was at land surface after completion of the well. After 24 hours, the water level inside the casing declined to 102 feet below land surface; however, water in the annular space around the casing of the well began to flow, probably from a higher aquifer. The well was slug tested by filling the casing with water. After 23 hours, the water level in the casing had declined only 7 feet, and then water in the casing rose to the surface and began to flow. The flow continued at a shut-in water pressure of 45 pounds per square inch, or a hydraulic head of 104 feet.

The 102-foot water level measured before the well began to flow was assumed to be representative of the hydraulic head in the coal aquifer. The decline in the water level from land surface to 102 feet below land surface is interpreted to be an adjustment to the pressure in the aquifer. An explanation for the well flowing after the slug test can be either of the following two hypotheses: (1) The perforated interval was not effectively sealed from overlying aquifers which have a higher hydraulic head causing the well to flow; and (2) slow evolution of gas from the coal decreased the density of the column of water causing the well to flow. Many flowing wells in the area have gas bubbles mixed with the water, and this well also bubbled gas. The quantitative effect of the gas pressure on the pressure head of the water has not been investigated.

Water levels in wells completed in coal beds correlated to the Wyodak-Anderson were used regardless of the "local" coal-bed name. Water levels in wells completed in the Anderson and in the Canyon were not significantly different near the outcrop in the northeastern part of the map, so water levels from wells in both coal beds were used.

POTENTIOMETRIC SURFACE

The water-level data from the Wyodak-Anderson coal bed appear to represent a continuous potentiometric surface in the Campbell County part of the Powder River structural basin. Although the surface is well defined along the eastern outcrop of the coal bed where most of the data are concentrated, it may be affected in places by local recharge and discharge. The one available water level in the central part of the basin is consistent with the potentiometric surface as drawn, even though it is 20 to 40 miles from the nearest data point. However, the data in eastern Sheridan County do not fit into this potentiometric surface, so a continuous potentiometric surface does not exist in the Wyodak-Anderson coal bed throughout the entire Powder River structural basin in Wyoming.

42N 069W 31BBC01	4744	195	12/80	4939	171-211	--	42R11P	Shell	
42N 070W 03CBC03	4653	163	--	4816	TD 260	--	BTR-20	Arco	
42N 070W 33ACD01	4595	176	08/78	4771	205-255	178-258	SEAM-18	USFS	
43N 070W 17BA 01	4608	71	--	4679	TD 196	--	BTR-1	Arco	
43N 070W 27AB 01	4621	60	10/73	4681	TD 118	--	BTR-154	Arco	
43N 071W 05DCC01	4616	229	08/78	4845	572-593	--	CDLTR-12	USGS	
43N 071W 21ADB01	4605	190	07/79	4795	--	--	--	USGS	
45N 070W 04BBB01	4600	87	--	4687	TD 113	--	CCR-3	Arco	
45N 070W 20BBA01	4639	231	05/79	4870	230-251	--	CDH-2	USGS	
45N 071W 05BAD01	4612	108	05/77	4720	290-311	308-	--	USGS	
45N 072W 36BCC02	4600	175	12/77	4775	673-693	--	HWY	USGS	
46N 070W 16CCC01	4628	44	--	4672	--	--	CCR-22	Arco	
46N 070W 18AAA01	4582	70	--	4652	TD 140	--	CCR-27	Arco	
46N 070W 27BDD01	4712	24	--	4736	TD 70	--	CCR-13	Arco	
46N 070W 29AAA01	4596	102	--	4698	TD 155	--	CCR-15	Arco	
46N 070W 33ACC01	4660	103	--	4763	--	--	CCR-6	Arco	
46N 070W 34CAA01	4704	38	--	4742	--	--	CCR-7A	Arco	
46N 071W 02DAC01	4486	54	--	4540	--	--	CORD-9	Sunoco	
48N 070W 18ADA02	4665	84	05/76	4749	--	--	CA-317	Carter	
48N 071W 11CCC05	4466	87	05/76	4553	110-170	102-173	CA-321	Carter	
48N 071W 12BAA01	4518	96	05/76	4614	--	78-121	CA-319	Carter	
48N 071W 31CA 01	4457	43	11/79	4500	200-268	--	WRRI-10A	Amax	
48N 077W 07DDD01	3993Q	102	06/83	4095	1045-1234	1040-1229	Big George	USGS	Water level explained in text
49N 071W 31ACC01	4463	137	12/77	4600	315-336	--	HWY	USGS	
50N 071W 05BAA01	4285	244	10/76	4529	--	--	EG6C	Kerr-McGee	
50N 071W 06BCB01	4306	184	10/76	4490	--	--	EG4	Kerr-McGee	
50N 071W 20BAD01	4418	12	03/77	4430	--	--	--	USGS	
50N 071W 21BBB01	4387	113	05/77	4500	125-	136-226	--	USGS	
50N 071W 33BAC01	4379	41	06/74	4420	95-152	101-156	HWY	USGS	
50N 071W 34BD 01	4429	41	08/78	4470	--	--	M-17	Wyodak	
50N 072W 13CC 01	4414	76	06/78	4490	--	--	Morries	USGS	
50N 072W 20AB 01	4467	--	--	--	--	--	--	USGS	Water level reported
50N 072W 23BB 01	4441	--	--	--	--	--	--	USGS	Water level reported
51N 072W 06ACC01	4140	50	--	4190	TD 281	209-	NRH-246	Carter	
51N 072W 11CCA01	4164	191	--	4355	TD 308	215-	NRH-2	Carter	
51N 072W 14AAD01	4203	--	--	--	--	--	NRH-268	Carter	Water level reported
51N 072W 21BBC01	4268	22	02/77	4290	42-75	--	GN-6	Amax	
52N 072W 33BBA01	4180	--	--	--	--	--	NRH-245	Carter	Water level reported
52N 075W 30AAA01	4024Q	241	04/84	4265	859-880	861-867?	Echeta	USGS	Anderson may be deeper
53N 074W 13DAD01	4045Q	125	10/81	4170	315-357	316-344	WK-12	USGS	Hole is open to 470 ft
54N 074W 07DAC01	3892Q	203	10/81	4095	418-450	429-451	SH-2	USGS	Hole is open to 550 ft
54N 077W 17BC 01	3694	116	08/84	3810	-430	--	--	USGS	
54N 077W 24ADD01	3703	87	02/79	3790	--	--	Malli	USGS	
56N 072W 29ACC01	3950	--	--	3950	Spring	--	WTB	USGS	
56N 072W 30BAB01	4020	--	--	4020	Spring	--	WTB	USGS	Canyon coal bed
56N 072W 32AC 01	3999	239	08/75	4238	245-260	--	RM-2	USGS	Canyon
56N 072W 32BAD01	4004	222	09/76	4226	214-252	212-248	BR76-102	USGS	
56N 073W 21AB 01	3928	178	08/75	4106	285-300	--	RM-6	USGS	Canyon
56N 073W 25BBA01	3988	207	11/79	4195	300-332	--	RM-3	USGS	Canyon
56N 073W 25CC 02	4068	74	05/76	4142	135-175	135-172	RM4-NE	USGS	
56N 073W 27CDC01	3973	213	09/75	4186	359-396	--	RM-5	USGS	Canyon
56N 078W 01AAB01	3672	363	08/84	4035	570-590	572-579	15-6-M	USGS	
58N 077W 19DBB01	3802	398	08/84	4200	546-567	542-560	7-11-M	USGS	
58N 083W 22DDD01	3475	60	04/84	3535	336-378	341-366	BND-15	USGS	

Water-level data from mine observation wells in the Wyodak-Anderson coal bed in the eastern part of the basin are compiled and contoured annually by the Gillette Area Groundwater Monitoring Organization (GAGMO) (Gillette Area Groundwater Monitoring Organization, 1983-85). The reports are published annually, showing the effects of mining on water levels. The maps cover a small part of the study area along the eastern coal outcrop. Local effects of mining, recharge, and discharge along the outcrop dominate the flow patterns shown on the maps. They present a detailed potentiometric surface in the coal that generally agrees with the regionalized premining potentiometric surface presented here.

GROUND-WATER FLOW

Ground-water flow in the Wyodak-Anderson coal bed generally is normal to the potentiometric contours but in places may follow available paths of secondary permeability. The direction of maximum gradient in most of the mapped area is to the northwest, toward the Powder River. In the southern part of the study area, recharge moves into the coal bed along the outcrop to the east (much of which consists of clinker). Water from the coal bed discharges to local drainages along the outcrop in the northern part of the study area and to overlying and underlying strata. The direction of flow in the western part of the basin is not known because of a lack of available data.

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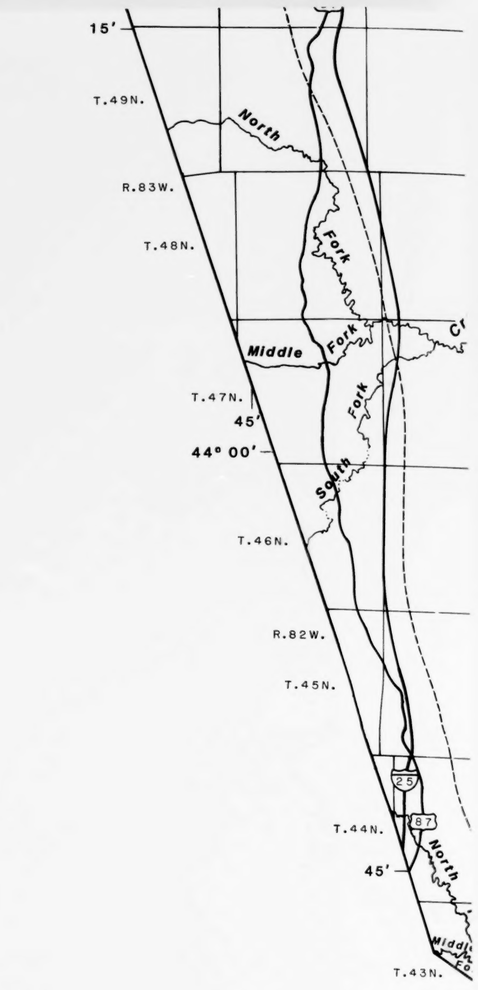
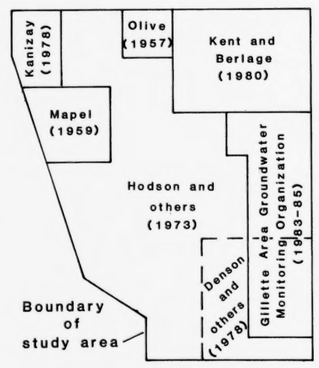




Index to geologic mapping

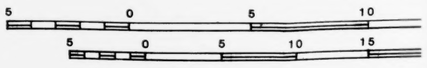
Base from U.S
1:250,000 qua
Gillette, 197
Sheridan, 196

CONVERSION FACTORS

For use of readers who prefer to use metric units, conve
factors for terms used in this report are listed below:

Multiply	By	To obtain
foot	0.3048	meter
mile	1.609	kilometer
acre	4,047	square met
pound per square inch	6.895	kilopascal

SCALE 1:250



POTENTIOMETRIC-SURFACE MAP OF THE WYODAK-ANDERSON CO

By Pamela

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Base from U.S. Geological Survey
1:250,000 quadrangles: Arminto, 1974,
Gillette, 1975, Newcastle, 1975, and
Sheridan, 1962

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P.O. Box 1125
Cheyenne, Wyoming 82003

metric units, conversion
ed below:

To obtain
meter
kilometer
square meter
kilopascal

SCALE 1:250 000

10 15 20 25 MILES

10 15 20 25 30 35 KILOMETERS

Hydrology mapped in 1984

ERSON COAL BED, POWDER RIVER STRUCTURAL BASIN, WYOMING, 1973-84

By Pamela B. Daddow

1986